

# **Plasma IMS Composition Measurements for Europa, Ganymede, and the Jovian System**

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NASA and ESA are now planning a reduced version of the joint Europa Jupiter System Mission (EJSM), potentially including a radically descoped Jupiter Europa Orbiter (JEO) but still with magnetometer and plasma instruments. Similar field and plasma instrumentation would also reside on ESA's Jupiter Ganymede Orbiter (JGO), which conceivably could carry out multiple flybys of Europa before entering orbit at Ganymede. We are developing the 3D Ion Mass Spectrometer (IMS) designed to measure both major and minor ion species within the high radiation environment of Jupiter's magnetosphere and the icy Galilean moons. The IMS covers the energy range from 10 eV to 30 keV, wide field-of-view (FOV) capability and 10–60 sec time resolution for major ions. This instrument has two main goals: 1) measure the plasma interaction between Europa and Jupiter's magnetosphere and 2) infer the global surface composition to trace elemental and significant isotopic levels; these goals are also applicable for in-situ measurements at Ganymede and Callisto, and remotely everywhere via the iogenic plasma for Io. The first goal supports the magnetometer (MAG) measurements, primarily directed at detection of Europa's sub-surface ocean, while the second goal gives information about transfer of material between the Galilean moons, e.g. mainly from Io to the other moons, and further allows detection of oceanic materials emergent to the moon surfaces from subsurface layers putatively including salt water oceans.

Outgassed exospheric materials are probed by the IMS by measuring pickup ions accelerated up to spacecraft altitudes of  $\sim 100$ – $200$  km in electric fields extending through the local magnetospheric environment and moon exosphere to the surface. Our 3D hybrid kinetic model of the moon-magnetosphere interaction is used to construct a global model of electric and magnetic fields for tracing of pickup ion trajectories back to the sources at approximate surface resolution of 100 km. We show that Europa's exospheric ionosphere is dominated by pickup ions with energies of 100–1000 eV. We also expect field aligned polar ion outflows driven by ionospheric electrons via the polarization electric field at Europa; the IMS will observe such outflows and thus sample the ionosphere below spacecraft orbit altitude  $\sim 100$  km. Based on previous Ganymede studies, we also comment on IMS applications to a Ganymede orbiter. The IMS and the Europa interaction model are respectively being developed with support from NASA's Astrobiology Instrument Development (ASTID) and Outer Planets Research (OPR) programs.